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Miniature Directional Coupler with Two Operating Frequency Bands

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Abstract. The design of the directional coupler with reduced physical dimensions, using compact structures. The proposed coupler operates at two Central frequencies, 900 and 1900 MHz. The use of compact structures instead of quarter-wave segments made it possible to reduce the standard coupler by 67%, with minor performance degradation.

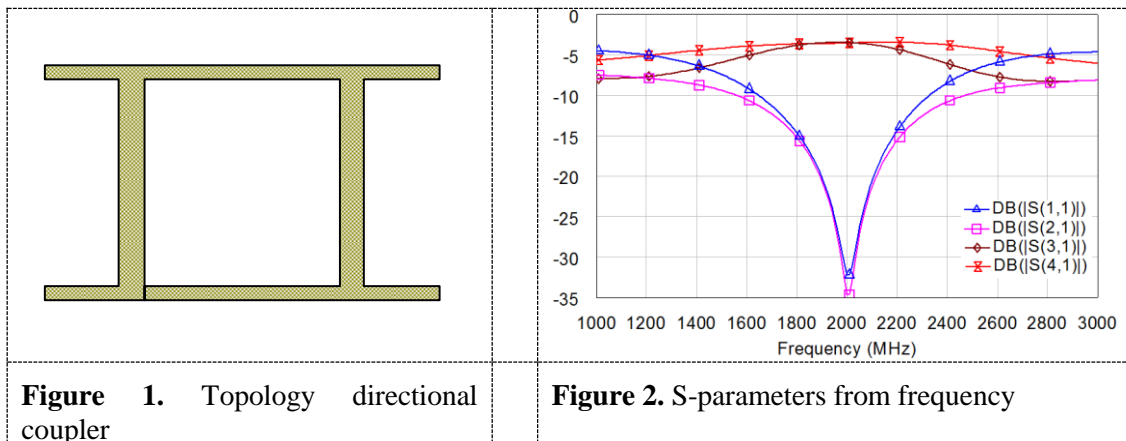
1. Introduction

In some cases it is necessary that directional couplers operate on several frequencies. This allows you to use such a device for several tasks at once. So the addition of idle loops in the standard design of the directional coupler allows to achieve the operation of the device in two operating frequency bands. Typically this frequency of 900 and 1800 MHz. At such frequencies, the traditional coupler takes up a lot of space, and for this reason, a procedure for miniaturization of its design is required. The literature describes many different techniques that can achieve good results in miniaturization, consider only a few works relating to the miniaturization of directional couplers. In [1] proposed to reduce the size using quasi-concentrated elements, in [2] equivalent transmission lines, in [3] U-shaped capacitances, in [4] periodic capacitive loads, asymmetric T-shaped structures in [5], low-pass filters in [6,7,8], slow-down systems in [9,10], artificial transmission lines in [11-13], fractal structures in [14,15], in [16] high-resistance elements, in [17] loaded loops, in [18-21] interdigital capacitors. In this paper, the design of the coupler was proposed by replacing four quarter-wave segments with compact structures having approximately similar characteristics at the Central frequency.

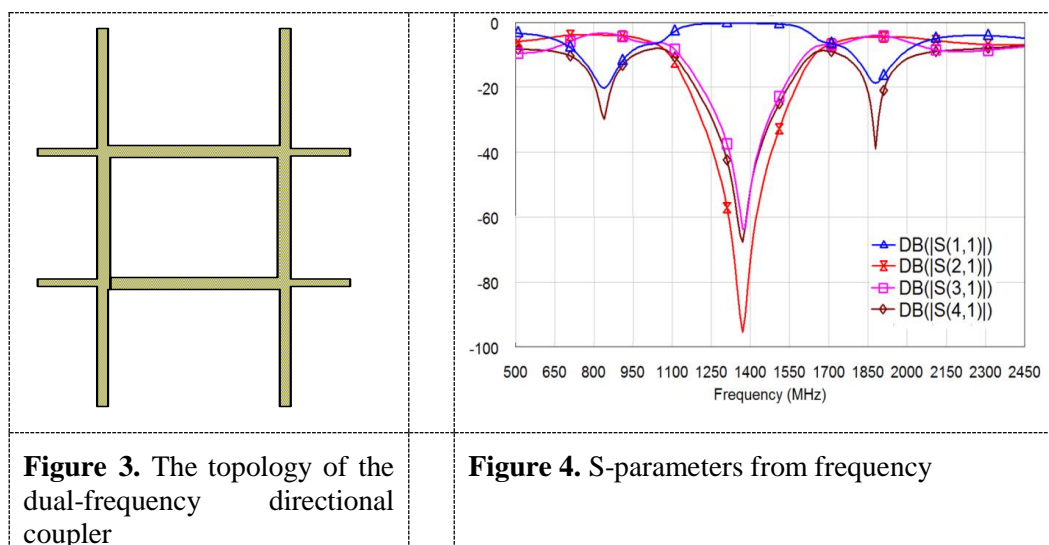
2. Design

Figure 1 shows the design of a directional coupler operating at one Central frequency, and figure 2 shows its frequency characteristics. The substrate material is a material with a dielectric constant of 4.4, a thickness of 1 mm and a loss of 0.02.

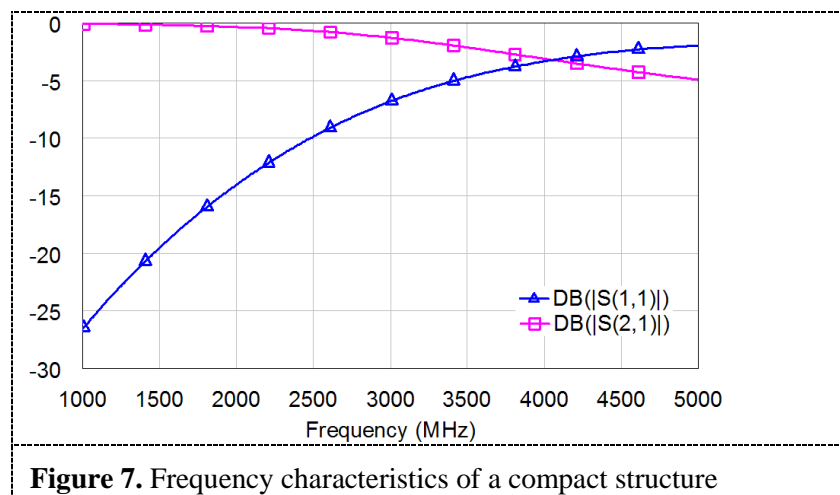
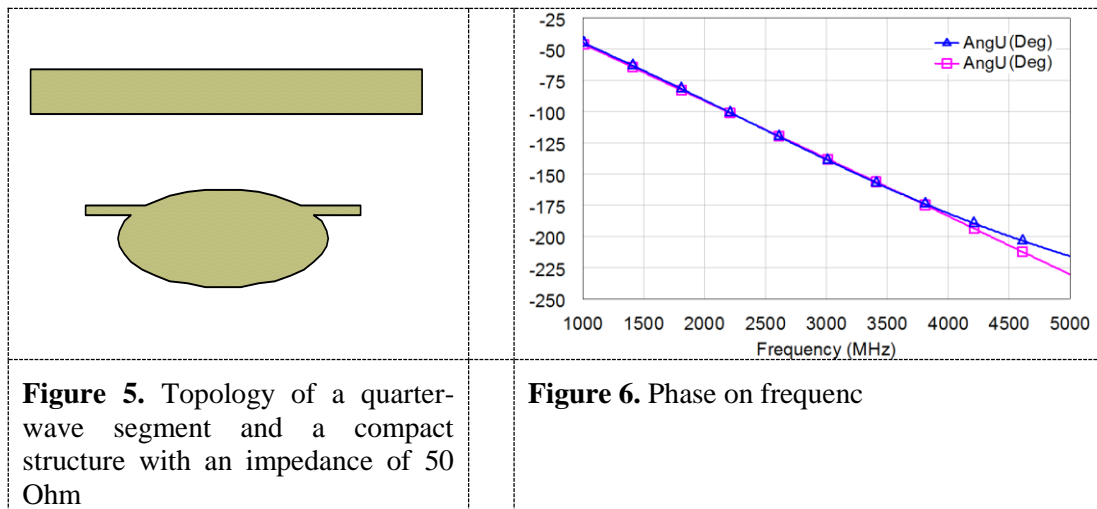




The addition of four idle loops, and the optimization of the design allows us to obtain the topology of the directional coupler [22], which divides the input power at two frequency ranges is 900 and 1800 MHz. The phase difference between the output signals at the two Central frequencies of the device must also be maintained. The topology of the coupler operating at two frequencies is shown in figure 3, and its frequency characteristics are shown in figure 4. After the standard design was designed and obtained, compact structures were synthesized, which allowed, after replacement, to reduce the overall dimensions of the coupler while maintaining its performance.



The area of a traditional coupler is 3020,3 mm². Operating frequency band estimated at the level of isolation -15 dB is 102 MHz. The second frequency band at the Central frequency of 1900 is 110 MHz. The imbalance between the output signals is 0.1 dB at 850 MHz and 0.15 dB at 1900 MHz. The compact structure is shown in figure 5 and its characteristics are shown in figures 6.7.



Based on the frequency characteristics shown in figures 8.9, it can be seen that the phase in the required frequency band coincides up to 3500 MHz. The transmission coefficient of the structure begins to deteriorate significantly after the frequency of 2500 MHz. After calculating the necessary structures on a substrate with a permittivity of 4.4 mm and a thickness of 1 mm, the topology of a compact two-frequency coupler operating at frequencies of 800 and 1950 MHz was obtained. The frequency shift is caused because of the distinctive phase characteristic of compact structures.

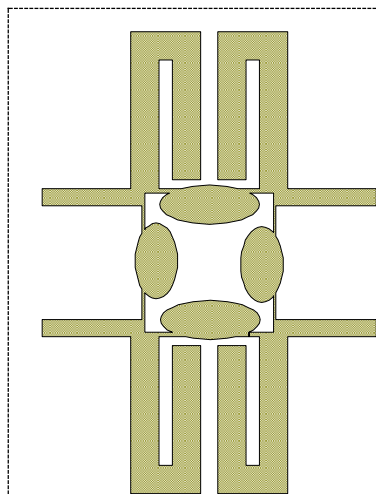


Figure 8. Compact dual-frequency directional coupler

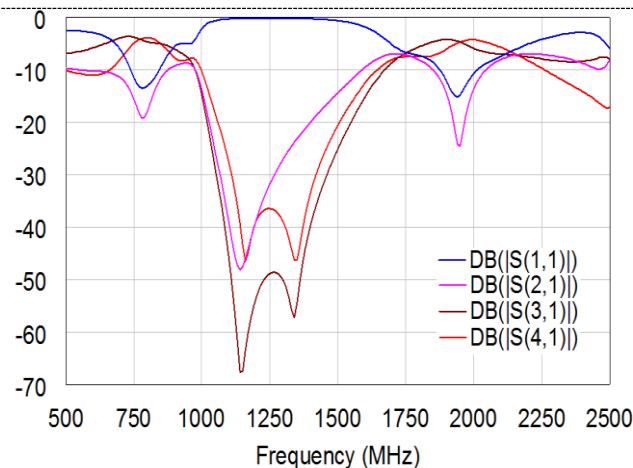


Figure 9. S-parameters from frequency

The area of the compact coupler is 998.6 mm². Operating frequency band estimated at the level of isolation -15 dB is 100 MHz. The imbalance between the output signals is 0.1 dB at 850 MHz and 0.15 dB at 1900 MHz. For comparison, the results were listed in table 1.

Table 1. Comparison of coupler

Design	Area, mm ²	1 Bandwidth based on 15 dB isolation level, MHz	2 Bandwidth based on 15 dB isolation level, MHz
Standard	3020,3	102	110
Compact	998,6	75	90

3. Conclusion

A directional coupler with reduced dimensions and operating at two frequencies of 900 and 1900 MHz was designed and investigated. Due to minor differences in phase and amplitude at the required frequencies, the difference from the characteristics of the standard design is an increase in the imbalance, the displacement of the Central frequency. The area of the device was reduced by 67%.

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